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Connecticut Agricultural Experiment Station
New Haven, Connecticut

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Fusicladium saliciperdum

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The Willow Scab Fungus

*Fusicladium saliciperdum**

G. P. Clinton and Florence A. McCormick

Introduction

The scab fungus of willows has been known in Europe for many years. In its parasitic stage it was found in North America for the first time in 1927 by the senior author (20). Years before, however, it had been reported, in what is claimed to be its saprophytic stage, from Greenland and Ellesmere Island by Rostrup (48). It is a relative of the common apple and pear scabs and has been called willow scab in Europe but its action on its most susceptible hosts has been so different from that of these scabs that the name willow leaf rot is more descriptive of its injury. It is the imperfect or conidial stage *Fusicladium saliciperdum* that, as a parasite, causes the injury to the willows while the asco or perfect stage occurs on the old dead leaves as a saprophyte only.

We have no fixed opinion whether this disease is native or has been introduced. The fact that it is very closely related to the poplar scab, which is native and has been known for years but which in 1928 assumed unusual vigor, might indicate it is also a native disease that, because of very favorable conditions, has suddenly sprung into unusual prominence from which it may subside, as it does in Europe.

On the other hand, while found here on wild willows, it seems to be confined, so far as seen by us, to the general vicinity where serious outbreaks have occurred on willows planted as shade trees. This might indicate its introduction on foreign stock planted in some of these infected regions, as has been claimed by some.

The willow disease must not be confused with the injury of willow-leaf beetles whose larvæ cause serious damage to the leaves by eating out holes, often skeletonizing them completely.

*We are indebted for aid in obtaining data of various kinds for this paper to Messrs. E. M. Stoddard, A. D. McDonnell, A. A. Dunlap and Mrs. Lillian D. Kelsey, of the Botanical Department. Specimens of diseased willows, collected both within and outside the state, have been sent by a number of interested people. Permission was granted by Luther M. Keith of the State Highway Department to spray street trees and by Mr. and Mrs. Henry F. Parmelee, to spray trees on their estate; both at Norfolk, Conn. Alfred Rehder, of the Arnold Arboretum, has verified many of our willow determinations. Dr. C. W. Dodge, of the Farlow Cryptogamic Herbarium of Harvard, has helped us with the literature and exsiccati references. C. O. Erlanson, of the University of Michigan, sent us specimens of willow leaves recently collected in Greenland, upon which we found *Venturia chlorospora* in its asco stage. Written December, 1928.

Injury of this nature has also been very conspicuous in certain sections of New England in the past season. Seen from the distance it is difficult to tell which one is causing the trouble.

Cesati (17) discoverer of the saprophytic stage, Allescher and Tubeuf (7) first describers of the parasitic stage, Karsten (30, 31), Rostrup (47-52) and Aderhold (2--3) were some of the earlier European botanists who made notes on this fungus. Aderhold, of Germany, was the first to definitely associate the two stages as now understood. In an article (2, pp. 80—3) published in 1897 on the scabs of birch, pear, poplar, apple, willow and ash he described both stages of the scabs on these hosts, placing the imperfect stage of each under the form genus Fusicladium and the perfect stage under the genus Venturia. The names applied to the two stages of the willow scab were designated as *Fusicladium ramulosum*, now known as *F. saliciperdum*, and *Venturia chlorospora*.

Recent investigations have been carried on by two European botanists concerning the parasitic nature of this fungus and its action on the willow. Dr. Marie Schwarz (60), of Holland in 1922, published a paper dealing with this and other parasitic fungi found on a species of weeping willow, *Salix alba* var. *vitellina pendula*, in the parks at Utrecht in 1920. Mrs. N. L. Alcock(4,5), of Edinburgh, Scotland, has more recently published two short papers dealing with its action on willow rods, *Salix alba* var. *vitellina*. Like Dr. Schwarz, she found a variety of other fungi associated with the death of the leaves and twigs some of which, besides the scab, were apparently parasitic. However, there has been some doubt even after these investigations as to how important the scab was in such outbreaks. We have attempted in our investigations to clear up some of the doubtful points in its life history and to determine methods of control by spraying.

PART I. AMERICAN INVESTIGATIONS

Distribution

The willow scab in its conidial stage was first definitely recognized in Connecticut, at Norfolk, in late June, 1927. Mrs. Parmelee who wrote to the Experiment Station of injury to her willows had, however, noticed the trouble the year before, but the cause had not been determined. Our visit to Norfolk was made some time after the leaves had been killed (Plate X, a) and many had fallen, so that at first we were not sure of the cause, thinking possibly a late frost, which was said to have occurred, might have been responsible. Identification was made more difficult by the fact that many of the leaves showed no fruiting stage of this fungus while other fungi had become more or less prominent on the dead tissues. The responsible fungus was soon located,

compared and found identical with European specimens of the willow scab. Now that its characteristic appearances are known it is easily recognized by us if present on the dead leaves or twigs.

Soon after its location at Norfolk, information was received from various sources of its presence in restricted localities in eastern New York, western Massachusetts and in near by locations in Connecticut, on both willow trees and shrubs. On a visit during August of 1927, the senior author also found the disease causing great damage to large willow trees at Weymouth and Digby in Nova Scotia (Plate XI, a, c,) and to a less extent at Greenwich in New Brunswick, Canada, and although the auto trip also included all the New England states except Vermont, it was not observed further in any of these.

To date, in Connecticut, the disease has been surely located in sixteen towns in the northwestern part of the state. These towns are Bridgewater, Canaan, Cornwall, Goshen, Kent, Litchfield, Norfolk, North Canaan, Salisbury, Sharon, Southbury, Torrington, Warren, Waterbury, Winchester, Woodbury. However, in three or four other towns removed from that region, occasional dead twigs of certain species of willows have been found that superficially resembled those seen on the willows in the infected district but, as the fruiting stage of the fungus was not found on any of them, we have left their identification as extremely doubtful. It is quite possible that in these cases the injury, resembling fireblight, was caused by bacteria, since they were sometimes found in the dead tissues. Bacterial diseases of this nature have been described elsewhere but as yet we have made no special study of such a trouble in Connecticut.

A camping trip, in late June, 1928, made by the senior author with students at Keene, New Hampshire, disclosed the fungus abundant on some highway trees in the town of Dublin. It has also been reported to us as occurring prominently in the Bridgewater valley in Vermont, although we have received no specimens from that state. In August it was found by the junior author in New York state on the Hudson-Hillsdale highway. Specimens have also been sent to us from the Lebanon mountain region in New York, found on the road from Pittsfield to Albany.

In July of this year a short auto trip from Canaan, Conn., north into the Berkshires through Sheffield, Great Barrington, Southbridge, Lenox and Pittsfield, Massachusetts, revealed the disease as common along the highway on the trees and shrub willows at these places. This is a region where large willows are very common and form a conspicuous part of the landscape. Specimens from this part of Massachusetts have also been sent to us for determination. The disease was seen by Mr. McDonnell of the botanical department in the vicinity of Easthampton and Northampton, but we have no record of its presence further eastward in Massachusetts, though it has been looked for as far east as Boston and from there north to the Maine line.

Early in the summer of 1928, Maine specimens were sent us from Salisbury Cove, on Mt. Desert Island, and from Brooklin, both in Hancock county. Later, in August, the senior author made an auto trip along Route 1 of the National Highway and saw diseased trees common from the state line at Calais all the way south to Bath, but few below the latter city. These infected trees were at or near the following cities: Calais, Pembroke, Dennysville, East Machias, Machias, Whitneyville, Harrington (Plate XII, c), Cherryville, Ellsworth, Salisbury Cove (Plate XII, d), Bar Harbor, Blue Hill, Brooklin, Bucksport, Lincolnville, Camden, Wiscasset, Wells, Kittery Point. The disease was reported by other observers from Belfast, Waldoboro and Goulds-boro.

Previous to the Maine trip the senior author also visited Nova Scotia (including Cape Breton Island), Prince Edward Island and New Brunswick and saw the disease on the susceptible species *Salix alba* var. *vitellina* practically everywhere it occurred over the 1200 miles traveled by auto. This species is a common street and shade tree in this region. The towns, or vicinities near them, where the disease was seen were as follows: In Nova Scotia proper at Yarmouth, Argyle, Shelburne, Liverpool, Bridgewater, Lunenburg, Mahone Bay, Hubbards, Black Point, St. Margarets Bay, Halifax, Waverly, Oakfield, Enfield, Stubenacadia, Stewiacke (Plate XI, b), Brookfield, Truro, New Glasgow, James River, Antigonish, Heatherton, Afton, Monastery; in Cape Breton Island at Margaree Forks, Margaree Harbor (Plate XI, d), Cheticamp, Badeek, Sydney, Big Pond, Big Pond Center, Cleveland; in Prince Edward Island at Charlottetown, North River, New Haven (Plate XII, a); in New Brunswick, at Cape Tormentine, Sackville, Moncton, (Plate XII, b), Salisbury, Sussex, Hampton, St. George, St. Andrews and at various places between those last mentioned. We also understand that the disease has been found in Quebec though we have seen no specimens from there.

Hosts

Fusicladium Stage:

More attention has been paid by us to determine the species of willows attacked in Connecticut than elsewhere, so most of the species reported here are from this state. Those on which we have found the fungus are as follows:

1. *Salix alba*: Conn., Me.
2. *S. alba* var *vitellina*: Conn., Mass., Me., N. H. (this may be *S. alba* x *fragilis* = *S. rubens*, according to Rehder), N. Y., Vt.; N. Scotia proper, C. Breton Isl., P. Edw. Isl., N. Brunsw.
3. *S. cordata*: Conn., Mass.; P. Edw. Isl.
4. *S. discolor*: Conn.

5. *S. lucida*: Conn.
6. *S. nigra*: Conn., Mass., N. Y.
7. *S. pentandra*: Conn., Me.; N. Scotia proper.
8. *S. sericea*: Conn.
9. *Salix* sps. undet.: Conn., Me.; N. Scotia.

Venturia Stage:

From literature we have learned of the North American distribution of the asco stage as follows:

1. *Salix arctica:* Ellesmere Isl. (Rostrup), Greenland (Lind).
2. *S. arctica* var. *Brownei*: Greenland (Lind).
3. *S. glauca*: Greenland (Rostrup).
4. *S. grœnlandica:* Greenland (Rostrup).
5. *S. herbacea:* Greenland (Rostrup).
6. *S. reticulata:* Greenland (Lind).

Besides the above we have recently received specimens of dead willow leaves collected June 1, 1928, at Englishman's Harbor, Disko Island, Greenland, by C. O. Erlanson of the University of Michigan. The leaves were collected for *Rhytisma salicinum* (Pers.) Fr., but also had other minute ascomycetes on them. On one of the leaves of these we found the asco stage of *Venturia chlorospora*, (spores more nearly var. *canescens* as they varied from 5.5-8*u* x 16-21*u*, chiefly 16-18*u*, and the asci from 14.5-16.5*u* x 48-54*u*, bristles on perithecia infrequent, perithecia commonly 90-100*u* in diameter), on this additional following host:

7. *S. chloroclados* x *glauca:* Greenland (Erlanson).

Susceptibility and Resistance

There seems to be at least some difference in the susceptibility of different species of willows to this fungus (Plate IX, a-b, free). There has also been quite a difference in its attack on susceptible individual trees and shrubs of the same kind even when growing close together. This latter difference we explain on the supposition that the disease had previously become well established on the badly infected plants, through overwintering on the branches, but not as yet on the less infected individuals and that the spores are washed or carried over the former much more readily than to adjacent plants. In time, however, if conditions prove favorable, the latter should become badly infected. For example, along the highway from Norfolk to Canaan there are numerous large willows, some apparently of the same variety as those in the village yet the disease gradually decreases outside of Norfolk to become inconspicuous at Canaan several miles distant. Some of these trees, however, may be crosses with *Salix alba* (Plate IX, c). At Calais, Maine, there is a row of *Salix alba* var.

vitellina of about a dozen trees reaching from the water to the highway. Those next the road were badly diseased in August, 1928, while those near the water (Plate IX, d) showed very little injury.

On the other hand *Salix alba* (Plate IX, a, shows catalpa and willow), although reported infected in Europe, seems to be resistant here, since we have rarely found it on that species even where the disease exists nearby on its variety *vitellina* which is the most susceptible of all the willows yet observed.

On two of the estates at Norfolk are several trees determined by us as the Bay-leaf willow, S*alix pentandra*, but although these are very near badly diseased trees no disease was found on them in 1927 and only occasional infected leaves in 1928. This species, however, seems to be one of those infected in Maine, although not as seriously as var. *vitellina*. *Salix nigra* is another large shade tree that has been rather badly injured though the fungus does not seem to fruit so abundantly on it. *Salix cordata* (Plate X, c) is apparently the most susceptible of the native willow shrubs. So far we have not seen the disease on the weeping willow, *Salix babylonica*, although it occurs occasionally in the infected regions and is reported from Europe as a host.

Injury to Trees

The worst injury to large trees, mostly S*alix alba* var. *vitellina*, was seen at Norfolk, Conn. (Plate X, b), Hancock county, Maine, and general in Nova Scotia. In the last region, according to a farmer interviewed, the disease, as in Connecticut, appeared conspicuously in 1926 but much more so in 1927. When first seen by the senior author in August of the latter year (Plate XI, a, c), some of the large trees had no, or very few, leaves on them and could easily be mistaken for dead trees. In 1928 in different parts of Nova Scotia hundreds of dead trees were seen and many more so badly injured that another season's attack was likely to finish them (Plate XI, b, d). The situation in Maine, in Hancock county along the coast (Plate XII, c, d), was not much better.

At Norfolk, by the end of June, 1927, the very large trees of *Salix alba* var. *vitellina*, which are conspicuous shade trees in the village, were partly to largely defoliated although later some new leaves were put out. In 1928, with an unusually wet spring and summer, by the first of August there was not a single untreated tree of this variety (Plate X, b) that was not completely or very nearly completely defoliated and very few if any new leaves were put out. It looks as if many of these trees were doomed, as they have gone through at least three seasons of more or less complete defoliation, and early this season most of the smaller twigs and many of the large branches were dead. Already several fairly young trees have been killed or so severely injured that only the

main trunks are alive. These trees were so weakened by the general attack on the leaves and young twigs very early in the several seasons that starvation and winter injury killed the large branches which were not directly attacked.

Bad as healthy willows are in littering the ground with dead twigs, after passing through last winter, the litter of twigs on the ground under the infected trees was unusually conspicuous, although only a comparatively few had yet broken off. We have seen no fungous disease of trees where the injury has been so sudden and severe as from this fungus, though the chestnut blight and the white pine blister rust in the long run cause more serious financial loss and eventually just as serious injury to the trees.

The fungus carries over the winter on the young twigs infected the previous year. In the spring the Fusicladium stage appears on these and the spores are washed down on the very young leaves in the opening buds, so that their death may occur before they have reached any size, much as occurs with the leaves of the sycamore from the anthracnose fungus. Some young leaves, however, escape infection only to succumb later. If the moist favorable weather continues, nearly full grown, or even full grown, leaves may suddenly rot on the trees and adhere there for some time, presenting a very mournful sight. They then dry up and gradually fall off leaving the trees more or less completely defoliated. Bad defoliation two or three years in succession seems to be fatal since after the first year, little adventitious foliage is put out and gradual starvation results.

If the tissues of the leaves are fairly mature when first infected, the infection may stop after killing spots of varying size in the otherwise healthy green tissues (Plate XIII, b). Often where the large, but still young, leaves are attacked the rot spreads down the midrib to the base killing the tissues as it advances. Quite frequently in these cases it reaches through the petiole into the tissues of the young twigs and causes a more or less conspicuous canker there (Plate XIII, a). If girdling occurs the twig, with its attached leaves above, soon dies. These dead twigs and leaves assume a reddish-brown or blackish color according to the species of willow. The fruiting stage may or may not be found on the dead twigs and leaves, apparently developing much more on some willow species than on others and, of course, not developing on tissues that have been indirectly killed by the action of the fungus.

The Fungus

The spring and summer of 1928 were unusually favorable not only for this scab but for all related scabs. Apple scab obtained an early start and its injury was much greater than in ordinary years; Pear scab, too, was more prominent than usual. Although known in New England for some time, we had not previously

listed the Poplar scab, *Fusicladium radiosum* (Lib.) Lind (*F. ramulosum, F. Tremulae*) from Connecticut. This year it has been found common not only in this state but in New Hampshire, Vermont and Massachusetts.

The chief aid in identifying the presence of the willow scab is the characteristic appearance of its fruiting stage. This develops usually on the under side of the leaves but is rather infrequent on the cankered areas of the young twigs. It may appear on these latter next year in early spring and produce the first infection of the leaves. It shows on the leaves as small dense olive-brown pustules which more or less cover the surface, but which particularly follow the downward course of the larger veins and especially the midrib (Plate XV, a).

The spores are olive to reddish-brown in color. They are truncate at the base, generally rounded at the apex, and have one, rarely two, or very rarely three septa. They vary from 12*u* to 25*u* long and from 6*u* to 10*u* wide. When two-celled, the basal cell is usually considerably longer and is somewhat broader (Plate XV, d). They are borne singly at the tips of the conidiophores. Apparently only one spore is formed on each conidiophore.

In cultures there is formed a dense velvety olive-brown growth on which the spores are usually abundantly developed in two to three weeks (Plate XV, b). The spores are somewhat larger than in nature, varying from 9-12*u* x 18-36*u*, and largely disappear through germination in old cultures. With age the mycelium is of similar color to the spores, moderately septate and branched and varies from 2.5*u* to 7.5*u*, chiefly 4-6*u*, in diameter. Not infrequently rounded, larger cells (9-15*u*) occur in the mycelium but are not thickened like chlamydospores. In old cultures imperfect perithecia appear somewhat sparingly. We have not yet been able by crossing with other species of Fusicladium or by stimulation to bring them to maturity. They appear similar to the immature perithecia we have found on sections of leaves, mentioned later.

The conidiophores on the leaves are closly compacted together to form the fruiting pustule. They arise from a more or less extended sclerotial mass of rounded cells (Plate XV, c) from which they are not always very clearly marked off. In general their erect habit, their brownish color, about the same as that of the spores, and their separation from each other above serve to distinguish them. They have one to several septa and at their base they gradually merge into the cells of the sclerotial mass. As a rule they are as long or longer than the spores and slightly narrower. Occasionally sections through the old leaves show more elongated, fewer and laxly clustered conidiophores that have borne spores both at and near their tips. We believe that these are always the conidiophores of the saprophytic Cladosporium.

Although the writers have made attempts to locate the Venturia stage of this fungus as described by Aderhold on the old leaves, have searched the twigs and leaves during the growing season and examined them especially at the time in the spring when infections from this stage would naturally take place, we have as yet failed to find it. Occasionally, however, in the sections made of infected leaves taken from the trees, we have found immature perithecia closely associated with the Fusicladium that may be the asco stage. Apparently, no one has yet made cultures from the Venturia stage and by this means, or by inoculations, proved its relationship to the Fusicladium. We have little doubt that the Venturia fungus eventually will be found here. We do doubt, however, if it is the asco stage, that it is as important in primary infection (unless occurring on the twigs on which it has not yet been reported) as the Fusicladium stage produced in early spring on the twigs from the overwintered cankers. This condition has also been found to be true with certain hosts of the pear and apple scabs in Connecticut and in England.

Associated Fungi

As stated earlier in the paper, certain of the workers with the Fusicladium stage of this fungus have found other fungi associated with it, some of which they have considered parasites and so apparently responsible for part of the trouble in the outbreak. Dr. Schwarz (60), for example, mentions three parasitic fungi, one of which, *Phoma intricans*, is described as new. The second is an ascomycete belonging to the genus Physalospora, determined by her as *P. Salicis* (Fckl.) Rab. She also notes that two other species of Physalospora, *P. gregaria* Sacc. and *P. Miyabeana* Fuk., have been mentioned as parasites of the willow. Lastly she gives *Discella carbonacea* (Fr.) Berk. & Br. as the third parasite.

Mrs. Alcock (5) in her article mentions the following fungi occurring on willow rods as parasites of greater or less intensity: *Physalospora gregaria* Sacc., *Cryptomyces maximus* (Fr.) Rhem, *Scleroderris fuliginosa* (Pers.) Karst. and *Myxosporium scutellatum* (Otth) Petrak.

Very recently Nattrass (42, 43), of England, has published articles on the parasitism of *Physalospora Miyabeana* Fuk., in relation to *Fusicladium saliciperdum*, as a cause of the disease of willows. Contrary to other investigators he is inclined to believe that the willow scab, at least in England, plays a secondary part to the Physalospora. He makes the following statement at the conclusion of his second article (43): "From these preliminary observations and experiments it appears that on the basket willow in Somerset *F. saliciperdum* cannot be regarded other than as a follower of *P. Miyabeana* and that it is in no way responsible for the symptoms of the disease on the leaves."

In our examination of the diseased willow leaves and twigs we have not paid especial attention to the other fungi that occurred on the dead tissues. We have, however, noted species present belonging to the following genera: Coniothyrium, Cladosporium, Alternaria, Fusarium, Cryptostictis, Monochætia, Pestalozzia, Glœosporium and Physalospora.

We have considered only the Glœosporium and the Physalospora, of the other fungi observed by us, as possible parasites. A culture of each from twigs was obtained by the junior author. The latter fungus seems to agree with the Physalospora described by Nattrass. Likewise it approaches *Glomerella cingulata* the common bitter rot fungus that is often a serious parasite on various hosts in the United States, but preliminary inoculations of apples with it (with one exception) and with the Glœosporium from the willows failed to take while those made at the same time with cultures of the bitter rot fungus were all successful. Further study is needed before we can definitely state their identity. We have, as yet, made no inoculations with cultures of these fungi on willows so judge of their parasitism merely from their appearance in nature, especially on twig cankers. However, if we consider the results of our infection experiments with pure cultures of *Fusicladium saliciperdum*, recorded here later, both, if involved, are secondary parasites in causing the willow disease in this country.

It is interesting to note that the three writers mentioned here, as well as ourselves, have all found a species of Physalospora (or by some it might be considered Glomerella) associated with the willow trouble. It is possibly the same fungus in all cases, although each of the writers noted gives a different specific name to it.

Infection Experiments

Apparently in Europe not much has been done dealing with artificial cultures of the willow scab, or inoculating willows with such cultures. Nattrass (42, 43) of England, however, has recently obtained cultures of the fungus but reports failures from his inoculations. The writers, therefore, have made special efforts along these lines. The junior author, in 1927, obtained cultures of the Fusicladium stage of the fungus from material collected at Norfolk. The chief difficulty in isolating these cultures is to avoid the common and saprophytic species of Cladosporium which is frequent on the dead willow leaves.

Infection experiments with these pure cultures were carried on at the Station laboratory at New Haven in the spring of 1928 on cuttings of various willows kept in water in battery jars. These did not prove very effective. While the leaves of the inoculated shoots died sooner, in most cases, and the contrast in the early period with the checks was usually evident and sometimes marked, the fungus did not fruit on the inoculated shoots possibly because of unfavorable conditions not yet determined.

Later, June 4th, leaves mostly immature were inoculated in Petri dishes with spores from these same cultures. The spores were sprayed over the leaves and four days later, while the leaves were still entirely green and showing no signs of injury, they were fixed and later sections made of them. Careful search of these sectioned leaves occasionally revealed germinating spores next the epidermal cells with rarely an indication that a germ tube had pushed in the wall between two adjacent cells. Mycelium similar to that of the Fusicladium was found sparingly in certain sections between the cuticle and epidermal cells and between and under the latter. In no case, however, were we able to actually connect the germinating spores on the outside with mycelium within the tissues. We do not, therefore, assert that these inoculations were successful although the results seem to indicate that they were.

Other experiments, however, carried on at about the same time at the Mt. Carmel farm of this Station, on growing basket willow shoots in an isolated place (Plate XVI, foreground of inset) where the disease is unknown for many miles, proved very conclusively that the scab fungus isolated from the Norfolk willows was responsible for the injury. Seven inoculations (April 13, April 27, May 7, June 4, June 14, June 20 and July 11) were made on these willows, beginning before the leaf buds were open on some of them, just as they were opening on others, on various stages of leaf growth and ending with the fully grown leaves. These inoculations were made usually in the afternoon on cloudy days or just before rains. With an atomizer containing water in which was an abundance of spores from the cultures, the sprouts were sprayed from the top to bottom with a fine mist. Then with a medicine dropper additional material was dropped on the leaves and buds here and there.

The typical disease appeared as the result of all these inoculations, except the last, killing the young leaves and finally the young stems, spotting the more mature leaves, producing cankers at the base of the infected leaves and finally fruiting in normal manner on the leaves and occasionally on the dead shoots. Uninoculated shoots at the further end of the inoculated rows remained free from the disease. There were five different varieties of basket willows in the experiment. These had been received from the U. S. Dept. of Agric., several years before, and were labeled Purple No. 2 (*S. purpurea*), American Green (*S. cordata* ?), American (*S. cordata*), Common Purple (*S. purpurea*) and Lemley (*S. lucida* ?). At the time of the first inoculation on April 13, the condition of the buds on the different varieties was as follows: Purple No. 2, leaf buds out the most of any; American Green, catkins only out; American and Common Purple, leaf buds out a little; Lemley, leaf buds not out at all.

From the tables that follow it appears that the American willow, *Salix cordata* (Plates XIII, b, and XVI) was by far the most sus-

ceptible and the American Green and Lemley moderately susceptible, while the purple varieties were only slightly susceptible. Not all of the inoculations took equally well, those made April 27 and May 7, after the buds were open but before the leaves were fully developed, were the best. With *Salix cordata,* however, the earliest inoculation of April 13 was also very successful since the leaf buds were somewhat open on that date. The last inoculations, made on July 11, apparently were not successful in any case.

TABLE 1.—SHOWING NUMBER OF TWIG INFECTIONS (FIRST FIGURE) AND LEAF INFECTIONS (SECOND FIGURE) ON JUNE 4.

Variety.		Date of Inoculations and Results.		
		April 13	April 27	May 7
Purple No. 2	Row 1	14–?*	?–11	0–1
American Green	Row 2	0–0	2–24	2–13
	Row 3	2–4	4–21	0–6
American	Row 4	5–244	19–130	0–31
	Row 5	4–60	20–73	0–76
Common Purple	Row 6	3–8	4–2	0–3
Lemley	Row 7	3–1	14–21	4–6
	Row 8	0–4	6–8	8–16
	Row 9	0–0	1–2	5–35

*Tip of twigs with very young leaves all killed.

TABLE 2.—SHOWING NUMBER OF INFECTIONS (FIRST FIGURE) ON NUMBER OF INOCULATED WILLOW SPROUTS (SECOND FIGURE) TAKEN ON JUNE 27.*

Variety.		Dates of inoculations and results.							Av. inf. per sprout
		April 13	April 27	May 7	June 4	June 14	June 20‡	July 11*	
Purple No. 2	Row 1	14 on 17	13 on 12	3 on 7	2 on 5	0 on 5	0 on 6	0	.6
American Green	Row 2	3 on 4	59 on 8	29 on 9	27 on 9	9 on 6	0 on 6	0	3.5
	Row 3	18 on 4	58 on 7	54 on 11	21 on 7	6 on 4	0 on 6	0	
American	Row 4	245 on 16	143 on 9	79 on 5	70 on 7	26 on 6	12 on 5	?	10.7
	Row 5	89 on 7	112 on 7	65 on 6	46 on 7	21 on 6	15 on 5	?	
Common Purple	Row 6	13 on 32	11 on 13	4 on 10	1 on 7	3 on 6	1 on 6	0	.5
Lemley	Row 7	36 on 13	42 on 7	13 on 3	36 on 5	2 on 6	9 on 5	0	3.3
	Row 8	6 on 5	18 on 9	28 on 6	18 on 6	11 on 5	7 on 5	0	
	Row 9	4 on 4	2 on 6	44 on 7	66 on 8	7 on 7	17 on 5	0	

* Except counts of inoculations made on July 11 were taken on Sept. 27.
‡ Counts for this inoculation were probably made too soon to get all the infections.

The earlier inoculations were much more favorable for infection than the later ones. Omitting the last inoculation which seems to have been too late for any infection, if we take the results of all of

the first-three inoculations and compare them with all of those of the second-three, we find that the former showed 1205 infections on 244 rods or an average of 4.9 infection per rod as compared with 433 infections on 161 rods or 2.6 infections per rod on the latter. This would indicate that infection in nature takes place much more readily on very young or scarcely mature leaves than on the fully grown leaves which agrees with our observations made at Norfolk.

It was not easy to determine the exact number of infections that resulted from these inoculations; for instance, several infections may have occurred on the same leaf and run together, or the tip of the twig, with its adhering leaves, may have been killed as the result of several rather than one infection. Consequently the number of infections that took place as recorded here is probably under rather than over estimated. There were over 1600 separate infections of which over 100 showed in dead blackened twigs two to six inches in length or in cankers on the young stems at the base of an infected leaf. In Table 1 there is given the number of infections resulting from the first three inoculations, as shown from the examination of June 4. The first figure in the table indicates the number of twig infections that were found, while the second the number of isolated leaf infections. In the second table data are given for all the inoculations from an examination made on June 27, except for the last inoculation which was examined on Sept. 27th.

Spraying Experiments

In order to determine if this disease could be controlled by spraying, treatments were made on four large willows at Norfolk which had been seriously injured the two previous seasons by this fungus. The power sprayer shown in Plate XIV, a, was used and thorough treatments were given by the operator climbing the trees (Plate XIV, b). Five treatments were made on the following dates: April 18, May 4, May 18, May 25, and June 6. Two of the trees did not receive the first treatment which was made with Bordeaux mixture only. This was intended as the dormant treatment before the leaf buds began to open, but as the spring at Norfolk was very slow in developing the second treatment on all four trees was practically a dormant treatment also. The third and fourth treatments were made on the growing leaves when about one-third and two-thirds grown, and the fifth on the leaves just after they had reached full size. Because of the very wet weather after the last treatment if it had been succeeded by another, say the second which took place at the same stage as the first, the treatments would have been better placed and probably more effective. After the first treatment two of the trees were sprayed with home-made 4-4-50 Bordeaux mixture and the other two with commercial dry lime sulphur, three pounds to fifty gallons of water.

Considering that these trees had suffered severely from this disease the two pervious years at least and that about 50% of the young twigs and a number of the large branches were dead before the treatments were started, the results of the spraying were very encouraging. When examined on June 5th, as the disease was just beginning to show serious headway, there were comparatively few dead leaves on them when judged by the two adjacent unsprayed trees whose foliage was badly infected. See Plate XIV, c, d, for one each of the sprayed and unsprayed trees, photographed in August. Seen last late in September, while there were some dead leaves showing infection had taken place, there was considerable healthy foliage on the living twigs and all four sprayed trees had by far the best foliage of any of the trees of this variety in the village, since all the unsprayed trees were very largely or completely defoliated.

There was not much difference between the two trees sprayed with Bordeaux mixture and the two with lime-sulphur. No injury was noticed from any of these treatments. As the Bordeaux stuck much better, we are inclined to favor this fungicide so far. We believe where thorough and timely treatments are given and the trees are not too far gone with the disease, it can be checked and in time satisfactorily controlled by four or five sprayings made each year as follows: 1st, on the dormant trees just before the buds begin to open; 2nd, on the very young leaves emerging from the buds; 3rd, on the young leaves one-third to two-thirds grown; 4th, on the leaves just as they reach full size; 5th, if necessary in wet seasons, a week or ten days after the 4th treatment.

Additional Note.

March 31st, 1929. Since this paper was written (a summary of which was given before the Canadian Mycologists at their meeting in December, 1928) we have received a letter that raised the question whether *Fusicladium saliciperdum* or *Physalospora Miyabeana* was the principal cause of the disease in North America and Europe, citing the work by Nattrass in England, as well as observations made in Canada, as reason for believing that the latter fungus was the responsible agent.

We have, therefore, repeated our indoor infections with pure cultures of *Fusicladium saliciperdum*. We can now state more certainly than we did before that our indoor infections of willow rods in battery jars and of leaves in Petri dishes, previously reported, were due to the *Fusicladium saliciperdum* spores sprayed on them. Apparently this fungus does not fruit, at least readily, under these conditions. However, we secured all the types of infection before noted in this second test. While the fungus has not as yet fruited on the dead tissues, by washing infected pieces in sterile water, corrosive sublimate and again in sterile water, we were always able to recover the fungus in fruiting condition when these tissues

were placed in Petri dishes in nutrient agar and in no case did the fungus Physalospora contaminate the cultures.

We have also tried a few infection experiments with pure cultures of our so-called *Physalospora Miyabeana* and apparently got somewhat similar results with it. However, we need to repeat these inoculation experiments a number of times before we can say just what kind of infection results. We can state very positively, however, that it is not necessary for this fungus to be present to secure serious injury to willows from inoculations with *Fusicladium saliciperdum*, such as is characteristic in nature on their very young leaves in the spring. We are inclined to believe that *Physalospora Miyabeana* is more likely to be responsible for the less serious injury to the mature tissues later in the year, as we have found a disease on the mature leaves, with concentric lines of growth, that we think was caused by it.

In any case we believe Nattrass was wrong when he states that *Fusicladium saliciperdum* "is in no way responsible for the symptoms of the disease on the leaves". Just why Nattrass failed to obtain infection with *Fusicladium saliciperdum* on willow leaves we do not know. We are inclined to believe, however, if he used pure cultures of this fungus, it was either due to failure to inoculate young tissues, or to lack of continued favorable moisture conditions. It is very essential that these conditions prevail and their absence is apparently the chief reason why the disease is not serious in most years.

PART II. EUROPEAN HISTORY

In the preceding part we have dealt with the willow scab as it occurs in America, based chiefly on our own work. In the present part we aim to treat of it briefly in a historical way, dealing with the investigations made in Europe where both the saprophytic and parasitic stages were first discovered. From these investigations there has resulted a somewhat extended bibliography, a duplication of names resulting in a limited synonomy, the issuing of dried specimens in various exsiccati and much of our knowledge relating to the hosts and distribution of the fungus. We shall treat of these separately.

Synonomy

Venturia chlorospora (Ces.) Karst. Fung. Fenn. Exs. No. 957. 1870.

Sphaeria chlorospora Ces. in Rabh. Fung. Eur. No. 48. 30 My. 1859.

Sphaerella chlorospora Ces. et De Not. Comm. Soc. Critt. Ital. **1**[4]: 237. Ja. 1863.

Sphaerella ditricha Awd. *p. p.* in Rab. Fung. Eur. No. 943 1866.

(1) ? *Sphaerella canescens* Karst. Fung. Fenn. Exs. No. 895. 1869.

Venturia chlorospora (Ces.) Karst. Fung. Fenn. Exs. No. 957. 1870.

Venturia chlorospora Karst. *p. p.* Myc. Fenn. **2**: 189. 1873.

(1) ?*Venturia chlorospora* var. *canescens* Karst. Myc. Fenn. **2**: 190. 1873.

Venturia chlorospora Wint. *in litt.* in de Thüm. Myc. Uni. No. 560. 1876.

Fusicladium ramulosum Rostr. *p. p.* in Müll. Tidsskr. Skovs. **6**: 294. 1883.

Venturia chlorospora Wint. *p. p.* Rab. Krypt. Fl. **1**^{2}: 436. 1887.

Septoglœum saliciperdum All. & Tub. in All. et Schn. Fung. Bav. No. 485. 1895.

Venturia chlorospora Aderh. in Hedw. **36**: 82. Ap. 1897.

Fusicladium saliciperdum Tub. in Arb. Biol. Abt. Land-Forstw. Kaiserl. Gesundh. **2**: 567-70. 1902.

Fusicladium saliciperdum Lind in Ann. Myc. **3**: 430. 1905.

The preceding names indicate the synonomy as we have found it in the literature. We have had to depend for this information partly on the opinion of others as we have not critically examined the specimens listed in the exsiccati, though we have seen all of them and almost all of the references to literature reported here. Those we have failed to see are indicated by a star (*) before the name.

It appears from our investigations that Cesati was the first to describe this fungus, under the name *Sphaeria chlorospora*, in 1859 from specimens of the asco stage on species of willow (*Salix triandra, S. alba*) collected at Vercelli, Italy. A few years later in 1863, he and De Notaris changed the name to *Sphaerella chlorospora*. In 1866 Auserwald used the name *Sphaerella ditricha* to include this species as well as others now considered distinct on Betula, Salix, Sorbus and Fraxinus.

In 1869 Karsten described *Sphaerella canescens* from Finland and later, in 1873, named it as a variety of *Venturia chlorospora*, namely var. *canescens*, distinguishing it by very slight differences in the spores. Aderhold (2, p. 82), however, gives it as a synonym of *Venturia chlorospora*. We include it here not because we doubt its varietal difference but because we believe that all of the specimens collected on Salix need to be gone over thoroughly to determine what if any varietal or specific differences there are. Karsten, also, was the first to place the fungus under the

(1) Said to have differently tinted and narrower spores.

proper genus, Venturia, as he issued specimens on willow (Fung. Fenn. Exs. No. 957) in 1870 as *Venturia chlorospora*. Therefore he is quoted by us as the second authority for the specific name. Karsten, however, in 1873 used the name *Venturia chlorospora* not only for this fungus but also included with it the species on poplar which is now considered distinct.

Winter, likewise, as early as 1876 issued specimens of the asco stage, in de Thümen's exsiccati on Salix sps. under the name *Venturia chlorospora* with Wint. *in litt.* as the authority. In 1887 he (72) showed that he also included other hosts with it.

Ordinarily the mature stage is cited as *Venturia chlorospora* (Ces.) Aderh. This is because Aderhold (2) in 1897, brought together the two stages on the willow for the first time under this name and limited the species to Salix as a host. So much for the asco stage.

The parasitic stage was first called *Septoglœum saliciperdum* in 1895 by Allescher and Tubeuf (7) but in 1902 the latter (70) renamed it *Fusicladium saliciperdum*, three years before this name was applied to it by Lind. This would make the proper combination for this stage *Fusicladium saliciperdum* (All. & Tub.) Tub. Tubeuf in his article states that Dr. Merck first called his attention to the willow disease in 1884. Rostrup (47), apparently the first to recognize the disease in 1883, used an older name, applied only to the scab of poplar *Cladosporium ramulosum* by Desmazier (or by Roberge according to Rostrup and Tubeuf), to include both these species under the name *Fusicladium ramulosum*. Aderhold (2) used the name *Fusicladium ramulosum* Rostr. for the conidial stage of the willow scab only but recognized that the fungi on the willow and poplar were distinct, calling that on the poplar *Fusicladium Tremulae* Fr.

Exsiccati

Both stages have been issued in various exsiccati. Such as we have been able to find are given in the following lists.

Venturia Stage:

Sphaeria chlorospora Ces. Mspt. et herb. Rabh. Fung. Eur. No. 48. 30 My. 1859.

Sphaeria chlorospora Ces. Erb. Critt. Ital. No. 296. D. 1859.

?*Sphaerella canescens* Karst. Fung. Fenn. Exs. No. 895. 1869.

Venturia chlorospora (Ces.) Karst. Fung. Fenn. Exs. No. 957. 1870.

Venturia chlorospora Wint. *in litt.* de Thüm. Myc.Uni. No. 560. 1876.

?*Venturia chlorospora* (Ces.) Karst. f. *canescens* Karst. Rehm Asc. No. 840. (1884, date of coll.).

Venturia chlorospora (Ces.) Karst. Roum. Fung. Sel. Exs. No. 5838. (My. 1891, date of coll.).

Venturia chlorospora (Ces.) Aderhold. Krieger Fung. Sax. No. 1428. 1899.

Venturia chlorospora (Ces.) Karst. Sacc. Myc. Ital. No. 486. 1900.

Venturia chlorospora (Ces.) Aderhold. Rehm Asco. No. 1340. 1900.

Venturia chlorospora (Ces.) Aderh. Jaap Fung. Sel. Exs. No. 425. S. 1910.

?*Venturia chlorospora* (Ces.) Karst. var. *canescens* Karst. Tranz. et Ser. Myc. Ross. Exs. No. 122. 1911.

Venturia chlorospora (Ces.) Karst. Petrak Fl. Boh. et Mor. Ex., II, 1, No. 782. O. 1913.

Venturia chlorospora (Ces.) Aderh. Syd. Myc. Germ. No. 1565. (5 Jl. 1919, date of coll).

Fusicladium Stage:

Septoglœum saliciperdum All. & Tub. All. et Schn. Fung. Bav. No. 485. 1895.

Fusicladium saliciperdum (All. et Tub.) Lind. Krieger Fung. Sax. No. 2090. 1909.

Fusicladium saliciperdum (All. et Tub.) Lind. Kabát et Bŭbák Fung. Imp. Exs. No. 642. 10 D. 1910.

Fusicladium saliciperdum (All. et Tub.) Lind. Tranz. et Ser. Myc. Ross. Exs. No. 146. 1911.

Fusicladium saliciperdum (All. et Tub.) Ld. Petrak Fl. Boh. et Mor. Exs. II, No. 925. 1914.

Hosts and Distribution

Some of the names of the willows included here are probably synonyms. Because of the geographical changes in Europe in recent years, it is sometimes difficult to determine the distribution of the fungus in the countries as they exist today. According to the information gained we find that the Venturia and Fusicladium stages, with the authority for the same, have been reported as follows:

Venturia Stage:

Salix alba: Italy (Cesati); Europe (Rostrup).

S. [*alba* var.] *vitellina*: Italy (Saccardo).

S. aurita: Finland (Karsten); Germany (Aderhold).

S. Caprea: Denmark (Lind); Finland (Karsten); France (F. Fautrey); Germany (Aderhold, Henkel, Krieger, Schroeder); Moravia (Petrak).

S. cinerea: Germany (Aderhold, Schroeder); Saxony (G. Winter).
S. cuspidata: Europe (Rostrup).
S. fragilis: Europe (Rostrup).
S. glauca: Iceland (Rostrup).
S. herbacea: Iceland (Rostrup); Spitzbergen and Bear Isl. (Lind).
S. herbacea x *polaris*: Spitzbergen and Bear Isl. (Lind).
S. lanata: Iceland (Rostrup).
S. mollissima: Europe (Rostrup).
S. polaris: Spitzbergen and Bear Isl. (Lind).
S. reticulata: Spitzbergen and Bear Isl. (Lind).
S. triandra: Italy (Cesati).
S. viminea: Ungarn (Rehm).
Salix sp.: Brandenburg (H. Sydow); Finland (Karsten); Italy (Saccardo); Waldschlucht (Rehm).

Fusicladium Stage:

Salix alba: Bohemia (Kabát et Bŭbák); Denmark (Lind); Germany (Tubeuf, Lindau); Kursk, Russia (Potebnia).
S. alba var. *vitellina:* Scotland (Alcock).
S. alba var. *vitellina pendula:* Holland (Schwarz.). Bad.
S. americana: Germany (Janson, Appen); Silesia (Pape). Very susceptible. [Possibly our *S. cordata*.]
S. amygdalina: Saxony (Krieger).
S. aurita: Europe (Lind); Germany (Aderhold, Lindau).
S. babylonica: Germany (Tubeuf, Janson).
S. Caprea: Europe (Lind); Germany (Aderhold, Lindau).
S. cinerea: Europe (Lind); Germany (Aderhold, Lindau).
S. cuspidata: Europe (Lind); Germany (Tubeuf, Lindau).
S. fragilis: Europe (Lind); Germany (Tubeuf, Lindau).
S. fragilis x *pentandra:* Denmark (Lind).
S. japonica pendula: Denmark (Lind).
S; laurina: Bavaria (Allescher & Tubeuf).
S. mollissima: Denmark (Lind); Germany (Lindau).
S. nigricans: Germany (Tubeuf).
S. pentandra: Germany (Tubeuf).
S. purpurea: Germany (Appen, Janson). Not very susceptible.
S. viminalis: Germany (Appen, Janson). Not very susceptible.
Salix sps.: Bavaria (Tubeuf); Bohemia (Petrak); England (Nattrass).

Bibliography

No doubt there are other references to this fungus than those recorded here, but these include all we have been able to locate in the time and facilities at our disposal. Those we have not been able to verify in the original we have indicated by a star (*) before the author's name. Exsiccati references are not usually given.

1. **Aderhold, R.** Litterarische Berichtigung zu dem Aufsatze über die Perithecienform von *Fusicladium dendriticum* Wall. Ber. Bot. Ges. **13**: 54-55. 1895.
   Calls attention to investigations previous to his by Goethe-Geisenheim and Brefeld suggesting connection of Fusicladium on apple and pear to *Venturia chlorospora* in its broad conception.

2. **Aderhold, R.** Revision der Species *Venturia chlorospora*, *inæqualis* und *ditricha* autorum. Hedw. **36**: 67-83. Ap. 1897.
   Describes and figures both spore stages of six species of which the one on willows is called *Venturia chlorospora* (Ces.) Ad. and its conidial stage *Fusicladium ramulosum* Rostr. Lists hosts as: "Conidienform in Frühjahr auf lebenden, Perithecienform in Frühjahr auf todten Blättern von *Salix Caprea*, *aurita*, *cinerea* und anderen."

3. **Aderhold, R.** Die Fusicladien unserer Obstbäume, II. Teil I. Landw. Jahrb. **29**: 541-87. 1900.
   On page 550 says the name *Venturia chlorospora* must be used for the Venturia on Salix sps.

4. **Alcock, N. L.** A Dieback, and Bark Disease of Willows, attacking the young Twigs. Trans. Roy. Scott. Arb. Soc. **38**: 128-30. 1924.
   Gives short historical account of *Venturia chlorospora;* asco stage not found so far in Great Britain. Describes effect on host (*Salix alba* var. *vitellina*) of *Fusicladium saliciperdum* and gives spore measurements.

5. **Alcock, N. L.** Successional Disease in Plants as shown in Willow Rods. Trans. Brit. Myc. Soc. **11**: 161–7. Au. 1926.
   Describes willow scab, *Fusicladium saliciperdum*, in its effect on willow rods, *Salix alba* var. *vitellina*, as found in Scotland and mentions *Physalospora gregaria*, *Cryptomyces maximus*, *Scleroderris fuliginosa* and *Myxosporium scutellatum* as associated fungi on diseased willow shoots. Gives literature.

6. **Allescher, A.** *Septoglœum salicinum* (Peck) Sacc. Rab. Krypt. Fl. 1^7 : 626-7. 1903.
   States above fungus is distinct from *Septoglœum saliciperdum* All. and Tub.

7. **Allescher, A. et Tubeuf, C.** *Septoglœum saliciperdum* All. et Tub. All. et Schn. Fung. Bav. No. 485. 1895.
   Described as a new species in this exsiccati apparently before it was in the next reference.

8. **Allescher, A. et. Tubeuf, C.** *Septoglœum saliciperdum* Allescher et Tubeuf. Ber. Bayer. Bot. Ges. **4**: 38. 1896.
   Describe this species on *Salix laurina* from Bavaria; note that it was issued under this name in All. et Schn. Fung. Bav. No. 485.

9. **Anon.** Review. Rev. Appl. Myc. **2**: 92-4. Fe. 1923.
   Reviews Dr. Marie B. Schwarz article (*q. v.* 60) on Dying Twigs of Elms, Weeping Willows and Peach Trees.

10. **Anon.** Review. Rev. Appl. Myc. **4**: 199. Ap. 1925.
    Reviews Mrs. N. L. Alcock's article (*q. v.* 4), Trans. Roy. Scott. Arb. Soc. **38**: 128-30.

11. **Anon.** Review. Rev. Appl. Myc. **4**: 644. N. 1925.
Reviews articles by Pape (*q. v.* 44) who reported *Fusicladium saliciperdum* on willow rods, *Salix americana*, from Silesia where it was extremely destructive and gave directions for control. Pape thinks further investigation is needed to prove *Venturia chlorospora* the mature stage.

12. **Anon.** Review. Rev. Appl. Myc. **6**: 520. S. 1927.
Reviews article by Appen (*q. v.* 15) who stated that in the wet seasons of 1925 and especially 1926, *Fusicladium saliciperdum* devastated willow plantations in Germany, especially those of *Salix americana*, while *S. viminalis* and *S. purpurea* were affected to a slighter extent.

13. **Anon.** Review. Rev. Appl. Myc. **7**: 127. F. 1928.
Reviews article by Janson (*q. v.* 28) on *Fusicladium saliciperdum* which was bad in neighborhood of Berlin on soil deficient in potash. *Salix americana* was especially susceptible while crosses of *S. viminalis* with *S. purpurea*, *S. daphnoides*, *S. triandra* appeared to be immune; gives method of control by *nosprasen*.

14. **Anon.** Review. Rev. Appl. Myc. **7**: 129. Mr. 1928.
Reviews article by unannounced author (*q. v.* 78) which states there were complaints from all parts of Germany concerning a die-back of American willows, *Salix americana*, largely due to *Fusicladium saliciperdum;* carried on cuttings; gives means for control; says *S. purpurea*, *S. triandra*, *S. viminalis* appear to be immune.

15. **Appen, A. V.** Weidenschorf (*Fusicladium saliciperdum*). Ill. Landw. Zeit. **47**: 67-8. 4 F. 1927.
Notes very serious injury to basket willow (*Salix americana*) in the flood season of 1926 and less so in 1925; describes character of injury; *S. viminalis* and *S. purpurea* were also somewhat infected; worst in soil rich in nitrogen; gives suggestions for control. Gives references to articles on this disease by Dr. Max Wolff (No. 77), and Drs. S. Ludwigs and M. Schmidt (No. 75). See review by Anon. No. 12.

16. **Auerswald, B.** *Sphaerella ditricha* Awd. Rab. Fung. Eur. No. 943. 1866.
Issues it as "*Sphaerella ditricha* Awd. *in litt. et Mspt.*"; gives synonomy and notes differences on different hosts among which are Betula, Salix, Sorbus and Fraxinus. He makes the species to include more than is recognized today and the specimen issued with the note being on Fraxinus excludes it from the exsiccati of *Venturia chlorospora* as understood by us.

17. **Cesati, V.** *Sphaeria chlorospora* Ces. Mspt. et herb. Rab. Fung. Eur. **1**, No. 48. My. 1859.
Describes and figures the asco stage on leaves of *Salix triandra* and *S. alba* from Vercelli, Italy.

18. **Cesati, V.** *Sphaeria chlorospora* Ces. Erb. Critt. Ital. No. 296. D. 1859.
Issued specimens of the above; said to be on *Salix alba* and *S. triandra* from Vercelli, Italy.

19. **Cesati, V. et De Notaris, G.** Schema di classificazione degli Sferiacei Italici Aschigeri. Comm. Soc. Critt. Ital. **1**[4]: 237. Ja. 1863.
Place *Sphaeria chlorospora* Ces. under the genus Sphaerella.

20. **Clinton, G. P.** A New Disease of Willows appears in Connecticut. U. S. Pl. Dis. Rep. **11**: 87. Au. 1927.
Reports trouble caused by *Fusicladium saliciperdum* and the editor adds note. This is the first report of the disease in North America.

21. **Clinton, G. P.** Willow Scab (*Fusicladium saliciperdum*). U. S. Pl. Dis. Rep. **12**: 82. 15 Au. 1928.
Reports above from Conn., N. Y., Mass., N. H. and Me.; found on six species of willows in nine towns in northwestern Conn.; defoliated all trees of *S. alba* var. *vitellina* at Norfolk, Conn., except the sprayed.

22. **Clinton, G. P. and McCormick, F. A.** *Fusicladium saliciperdum* (Leaf Rot) on Willow. U. S. Pl. Dis. Rep. **12**: 54-5. 15 Jl. 1928.
Report this new American disease on willows from Conn., Mass., N. H., N. Y. in the United States and from Nova Scotia and New Brunswick in Canada; list hosts as *Salix nigra*, *S. alba* var. *vitellina*, *S. cordata* and possibly *S. sericea*; obtained culture of fungus and proved by inoculation experiments its parasitic nature; got results from four treatments with Bordeaux mixture and lime-sulphur.

23. **Dearness, J.** The Fungi of the Arctic Coast of America West of the 100th Meridian. Rept. Can. Arc. Exp. 1913-18, **4C**: 12C. Je. 1923.
Lists *Venturia chlorospora* as reported on *Salix arctica* from Ellesmere Island.

24. **De Notaris, G.** 97. *Sphaerella chlorospora.* Sfer. Ital. 1^2: 86-7, Tav. 97. 1863.
Gives synonomy, describes and figures fungus under above name. No setae shown on perithecia.

25. **Ellis, J. B. and Everhart, B. M.** *Venturia chlorospora* (Ces.). N. A. Pyrenomycetes: 138. 1892.
Give synonyms, exsiccati, scientific description of above and list on *Salix herbacea* and *S. glauca* from Greenland.

26. **Farlow, W. G. and Seymour, A. B.** *Venturia chlorospora* (Ces.) Karst. Host Index Fungi U. S.: 131-2. 1888.
List on *Salix glauca* and *S. herbacea.* (The revised Index will give hosts as *Salix arctica*, *S. arctica* var. *Brownei*, *S. glauca*, *S. grænlandica*, *S. herbacea* and *S. reticulata*).

27. **Henkel, A.** Neues und Bemerkenswertes der Pilzflora Thüringens. Ann. Myc. **21**: 146. 28 F. 1923.
Lists *Venturia chlorospora* on old leaves of *Salix Caprea* from Thüringia, Germany.

28. **Janson, A.** Ueber den Schorf und andere Korbweidenschädlinge. Nachr. ü. Schädl. **2, 3**: 161-4. Au. 1927.
Notes injury to basket willows in Germany, especially on ground poor in potash,by *Fusicladium saliciperdum* during warm wet weather of 1927; describes character of injury to the growing rods and contrasts with frost and hail injury; reports injury in past on *Salix bab(i)lonica* and other ornamental willows but especially bad now on American willow used for basket work while crosses of *S. viminalis* with purple Caspian and almond willows were less susceptible; thinks cutting rods in April rather than in winter may lessen the disease; gives methods of control by clean culture, spraying, etc. Also see review by Anon. no. 13.

29. **Karsten, P. A.** *Sphaerella canescens* Karst. Karst. Fung. Fenn. Exs. No. 895. 1869.
Gives description of above and lists on *Salix acutifolia.*

30. **Karsten, P. A.** *Venturia chlorospora* (Ces.).Fung. Fenn. Exs. No. 957. 1870.
Issues above on Salix from Finland.

31. **Karsten, P. A.** *Venturia chlorospora* (Ces.) Karst. Myc. Fenn. **2**: 189. 1873.
Describes above, gives synonyms and lists on *Salix Caprea, S. aurita* and *Pyrus malus;* describes as variety *canescens* (*Sphaerella canescens* Karst.) on *Salix acutifolia* which differs in slight spore characters (p. 190).

32. **Lind, J.** Über einige neue und bekannte Pilze. Ann. Myc. **3**: 427-32. 10 D. 1905.
Distinguishes (pp. 429-31) between the two species of Fusicladium on Salix and Populus, giving their correct names as *Fusicladium saliciperdum* (All. & Tub.) Lind and *F. radiosum* (Lib.) Lind (*F. Tremulae*), with the proper names for their asco stages as *Venturia chlorospora* (Ces.) Ad. and *V. Tremulae* Aderh. and lists *F. saliciperdum* on *Salix alba, S. aurita, S. Caprea, S. cinerea, S. cuspidata, S. fragilis* and *S. mollissima.* Does not separate Napicladium from Fusicladium as a distinct genus.

33. **Lind, J.** Systematic List of Fungi (Micromycetes) from North-East Greenland. Danmark-Eksped. til Groenl. Nord. 1906-08, **3**: 153. 1910.
Lists *Venturia chlorospora* (Ces.) Karst. on *Salix arctica* from Greenland. This is a separate from Medd. om Grønl. XLIII.

34. **Lind, J.** Fungi (Micromycetes) collected in Arctic North America. Reprint from Vid. Selsk. Skrifter, I Math.-Nat. Klasse **1909**^{9}: 7, 17. 1910.
Lists above fungus on *Salix arctica* var. *Brownei* and *S. reticulata* from Greenland.

35. **Lind, J.** 922. *Venturia chlorospora* (Ces.) Karsten. Danish Fungi in Herb. E. Rostrup: 212. 3071. *Fusicladium saliciperdum* (All. & Tub.). *Ibid.*: 520. 1913.
Lists *V. chlorospora* on *Salix Caprea* and *F. saliciperdum* on *Salix alba, S. fragilis* x *pentandra, S. japonica pendula, S. mollissima* and gives references to collectors and literature.

36. **Lind, J.** The Micromycetes of Svalbard. Det. Kongl. Dep. f. Hand. Sjøf. Ind. Händv. og Fisk. 1928: 21. 1928.
Lists *Venturia chlorospora* on *Salix herbacea, S. herbacea* x *polaris, S. polaris, S. reticulata* from Spitzbergen and Bear Island.

37. **Lindau, G.** Venturia Ces. et de Not. Engler u. Prantl Nat. Pflanz. **1**^{1}: 431. 1897. Septoglœum Sacc. *Ibid.* **1**^{1}** 407-8. 1900.
Describes genus Venturia and includes several species under *Venturia chlorospora* (Ces.) Karst.; describes genus Septoglœum and states that *Septoglœum saliciperdum* Allesch. et Tub. causes serious injury to *Salix laurina* in South Bavaria.

38. **Lindau, G.** *Fusicladium saliciperdum* (All. et Tub.). Rab. Krypt. Fl. **1**^{8}: 776. 16 My. 1907.
Describes, gives synonomy and lists above on *Salix alba, S. aurita, S. Caprea, S. cinerea, S. cuspidata, S. fragilis, S. mollissima,* in Denmark on the authority of Rostrup. Gives *Venturia chlorospora* as asco stage. States Rostrup wrongly included both the species on Salix and Populus under *F. ramulosum,* the proper name for the latter.

39. **Lindau, G.** *F. saliciperdum* (All. et Tub.) Lind (*Septoglœum saliciperdum* All. et Tub.). Sorauer Handb. Pflanzenkr. **2**: 444. 1908.
Lists above on Salix sps. as conidial stage of *Venturia chlorospora.*

40. **Martin, G. H.** *Fusicladium saliciperdum* (All. & Tub.) Lind. U. S. Pl. Dis. Rep. Suppl. 42: 341. 15 S. 1925.
Merely gives reference to Alcock's paper no. 4.

41. **Müller, P. E.** Bot. Centralb. **15**: 151-2. 1883.
Reviews briefly Rostrup's article (*q. v.* 47) on *Fusicladium ramulo* [*r*] *um* which occurs as a parasite on species of willow and poplar, giving description of injury and character of fungus.

42. **Nattrass, R. M.** Economic Mycology. Ann. Rep. Agr. Hort. Res. Sta. Uni. Bristol **1927**: 209, 211, 212. 1927?
Notes presence of *Fusicladium saliciperdum* on willow at Long Ashton; cultures were obtained. Worked with this fungus and *Physalospora Miyabeana* in relation to willow disease.

43. **Nattrass, R. M.** The Physalospora Disease of the Basket Willow. Trans. Brit. Myc. Soc. **13**: 286-306. 26 O. 1928.
Describes *P. Miyabeana* and its attack on *Salix alba* vars. *vitellina* and *cardinalis* and *S. americana*; gives culture characteristics and successful inoculation experiments; compares with *Physalospora gregaria Sacc.* and *P. Salicis* Fuckel and notes relationship to *Glomerella cingulata* (Stonem.) Spauld. & v. Schr.; credits it rather than *Fusicladium saliciperdum* as primarily responsible for the disease of basket willows in England.

44. **Pape, H.** Der Pilz *Fusicladium saliciperdum* (All. et Tub.) Lind als Korbweidenschädling. Deutsche Obst- und Gemüsebau-Zeitung **71**: 326-29. 12 Je. 1925.
Gives a short historical account and comprehensive description of the macroscopic appearance of diseased specimens sent him in February, 1925, from Brieg in Schlesien, where much injury had been caused to basket willows, especially *Salix americana*; notes appearance of disease similar to frost injury for which it may be mistaken; disease worst in very wet years and in situations with abundant nitrogenous matter in the soil; indicates control by clean culture, spraying and cutting rods in late spring rather than in winter or fall; holds above fungus fully responsible for the disease but questions whether connection with Venturia stage has been fully proven as yet. See also review by Anon. No. 11.

45. **Petrak, F.** Beiträge zur Pilzflora von Sternberg in Mähren. Ann. Myc. **25**: 344–88. 1927.
Lists *Fusicladium saliciperdum* (All. et Tub.) Lind, page 384, on living leaves and tips of twigs of Salix sp. on the banks of streams in low ground.

46. **Potebnia, A.** Beiträge zur Micromycetenflora Mittel-Russlands. Ann. Myc. **8**: 42–93. 1910.
States on page 90 that *Fusicladium saliciperdum* (All. et Tub.) Lind on *Salix alba* at Kursk, Russia, badly injured the leaves in June, 1909.

47. **Rostrup, E.** *Fusicladium ramulosum.* Fortsatte, Undersøgelser over Snyltesvampes Angreb paa Skovtræerne. [Separate from Müller's Tidsskr. f. Skovbrug **6**: 199-300. 1883.]
Treats on pages 294-6 of above fungus which he recognizes as a parasite; pictures spores and gives measurements; gives reference to *Cladosporium ramulosum* on *Populus alba* and credits Roberge rather than Desmazier as the authority as given by Saccardo and others, but uses *Fusicladium ramulosum* as proper name and includes as hosts *Populus alba, P. canescens, P. tremula, Salix alba, S. fragilis* and *S. cuspidata*, thus not distinguishing the two species as now recognized. See also review by Müller, No. 41.

48. **Rostrup, E.** Fungi Grœnlandiae. Separate from Medd. om Grønl. **3**: 556. 1888.
Lists *Venturia chlorospora* (Ces.) Karst. on *Salix herbacea* and *S. glauca* from Greenland.

49. **Rostrup, E.** Ost-Grønlands Svampe. Separate from Medd. om Grønl. **18**: 22. 1894.
Lists *Venturia chlorospora* (Ces.) Karst. on *Salix grœnlandica* from East Greenland.

50. **Rostrup, E.** Pileskurv. *Venturia chlorospora* (Ces.) Aderh. Rostrup's Plantepatologi: 464. 1902.
Has note on above and lists on *Salix alba, S. fragilis, S. cuspidata* and *S. mollissima.*

51. **Rostrup, E.** Islands Svampe. Separate from Bot. Tidsskr. **25**: 303. 1903.
Lists *Salix herbacea, S. lanata, S. glauca,* from Iceland, as hosts of *Venturia chlorospora.*

52. **Rostrup, E.** Fungi collected by H. G. Simmons on the 2d Norwegian Polar Expedition, 1898-1902. Rept. Sec. Nor. Arct. Exp. Fram, 1898-1902, No. 9: 7. 1906.
Lists *Venturia chlorospora* on *Salix arctica* from E. Bedford, Pim Island, Hayes Sound.

53. **Saccardo, P. A.** *Venturia chlorospora* (Ces.) Karst. Fungi Ital. No. 349. S. 1878.
Pictures perithecia, asci and ascospores on *Salix vitellina* from Italy.

54. **Saccardo, P. A.** *Venturia chlorospora* (Ces.) Karst. Sacc. Syll. Fung. **1**: 586-7. *Venturia inaequalis* (Cooke) Wint. *Ibid.*: 587-8. 1882.
Describes *Venturia chlorospora* and lists the hosts as Quercus, Salix, Pyrus, Prunus, Sorbus and Crataegus, but follows with short description of vars. of which var. *Salicis vitellinæ* is one. Describes as distinct *Venturia inœqualis* (Cooke) Wint. and lists as hosts *Pyrus Aria, P. communis, P. Malus* but not Crataegus, Salix, Fraxinus, etc.

55. **Saccardo, P. A.** *Venturia chlorospora* (Ces.) Karst. var. *canescens* Karst. Sacc. Syll. Fung. **9**: 687-8. 1891. *Venturia macrospora* Rostr. *Ibid.* **11**: 306. 1895.
States variety differs from *V. chlorospora* by differently tinted and narrower spores; reported on *Salix acutifolia* from Finland. Describes *V. macrospora* on *S. grœnlandica* from Greenland. It has much wider and longer asci and ascospores than *V. chlorospora.*

56. **Saccardo, P. A. et Sydow, P.** *Septogœlum saliciperdum* Allesch. et Tubeuf. Sacc. Syll. Fung. **14**: 1031. 1899.
Describes and lists host as *Salix laurina* from Bavaria.

57. **Saccardo, P. A. et Traverso, J. B.** *Venturia chlorospora* (Ces.) Karst. Sacc. Syll. Fung. **20**: 1123. 1911.
Give reference to illustrations of above fungus.

58. **Saccardo, P. A. et Trotter, A.** *Fusicladium saliciperda* (All. et Tub.) J. Lind. Sacc. Syll. Fung. **22**: 1376. 1913.
Give *Venturia chlorospora* (Ces.) Karst. as asco stage of above and *Septoglœum saliciperdum* as synonym. Notice spelling of *saliciperdum.*

59. **Schroeter, J.** *Venturia chlorospora* (Cesati). Krypt. Fl. Schl. **3²**: 351-2. 1894.
Describes genus and species. In the latter includes as hosts Crataegus, Apple and Pear (now considered as distinct from that on Salix) with *Salix Caprea* and *S. cinerea*, from Germany.

60. **Schwarz, Marie Beatrice.** Das Zweigsterben der Ulmen, Trauerweiden und Pfirsichbäume. Med. Phytopath. Lab. Willie Commelin Scholten, Baarn, V: 1-73. D. 1922.
Discusses on pages 33-49 "Das Triebsterben und der Rindenbrand der Trauerweide" caused by *Fusicladium saliciperdum* (All. et Tub.) Tub. on *Salix alba* var. *vitellina pendula* in Holland. Describes in detail effect on host and names saprophytes and parasites that follow on the weakened willows. Failed to get cultures and made no inoculations and not sure about the so-called asco stage.

61. **Stevens, F. L.** *Fusicladium saliciperdum* (All. & Tub.) Lind. The Fungi which cause Plant Dis.: 606. 1913.
Lists above as stage of *Venturia chlorospora* on Salix.

62. **Stevenson, J. A.** Foreign Plant Diseases. U. S. Dept. Agr.: 163. 1926.
Under Salix gives *Fusicladium saliciperdum* as a disease attacking *S. alba*, *S. aurita*, *S. Caprea*, *S. cinerea*, *S. cuspidata*, *S. fragilis*, *S. mollissima*, *S. nigricans*, *S. pentandra*; reported from Scotland, Russia, Denmark, Holland and Germany with *Venturia chlorospora* as perfect stage.

63. **Sydow, P.** *Venturia chlorospora* (Ces.) Karst. Sacc. Syll. Fung. **13**: 1078-1102. 1898. *Venturia chlorospora* (Ces.) Karst. var. *canescens* Karst. *Ibid.* *Venturia inæqualis* (Cke.) Wint. *Ibid.* *Venturia macrospora* Rostr. *Ibid.* *Septoglœum saliciperdum* Allesch. et Tub. *Ibid.*
Gives following willows as hosts of *Venturia chlorospora*, Salix sp., *S. Caprea*, *S. cinerea*, *S. glauca*, *S. herbacea*; for var. *canescens* gives *S. acutifolia*; for *Venturia inæqualis* gives Salix sp.; for *V. macrospora* gives *S. grœnlandica;* for *Septoglœum saliciperdum* gives *S. laurina.*

64. **Sydow, P.** Pilze. Just's Bot. Jahr. **37, I**: 159. 1912.
Notes Krieger, Fung. Sax. No. 2090, issued specimens of *Fusicladium saliciperdum* in 1909.

65. **Sydow, P.** Pilze. Just's Bot. Jahr. **38, I**: 147. 1913.
Notes Jaap issued *Venturia chlorospora*, No. 425 in Fung. Sel. Exs. in 1910.

66. **Sydow, P.** Pilze. Just's Bot. Jahr. **38, I**: 148. 1913.
Notes that *Fusicladium saliciperdum* was issued as No. 642 of Kabát et Bubák's Fung. Imp. Exs. in 1910.

67. **Sydow, P.** Pilze. Just's Bot. Jahr. **39, I**: 206. 1913.
Notes Tranzschel and Serebrianikow issued *Venturia chlorospora* (Ces.) Karst. var. *canescens* Karst, No. 122, and *Fusicladium saliciperdum* (All. et Tub.) Lind, No. 146, in Myc. Ross. Exs. in 1911.

68. **Sydow, P.** Pilze. Just's Bot. Jahr. **41, I**: 200. 1919.
Notes Petrak issued specimens of *Venturia chlorospora*, Fl. Boh. et Mor. Exs. II, 1, No. 782, in 1913.

69. **Sydow, P.** Pilze. Just's Bot. Jahr. **42, I**: 175. 1921.
Notes Petrak issued *Fusicladium saliciperdum*, Fl. Boh. et Mor. Exs. II, 1, No. 925, in 1914.

70. **Tubeuf, C.** Das Triebsterben der Weiden. Arb. Biol. Abth. Land. u. Forstw. Kaiserl. Gesundh. **2**: 567-70. 1902.
States the willow disease was first called to his attention in 1884 by Dr. Merck; gives description of the injury and discusses similarity to frost injury which Frank thought the fungus followed; copies original description of *Septoglœum saliciperdum*; discusses historical relationship to similar fungus on poplars and notes their differences and the right of the poplar fungus to the name *Fusicladium ramulosum*; renames the willow fungus *Fusicladium saliciperdum* Tub.; pictures spores of both species, the injured tips of willow twigs, as well as a cross section of a conidial sorus on *Salix pentandra*; reports *S. babylonica* and "other willows" as hosts; gives Ludwigs "Lehrbuch der niederen Kryptogamen" as reference for serious outbreak on willows in Burgundy reported by Vuillemin.

71. **Winter, G.** *Venturia chlorospora* Wint. *in litt.* de Thüm. Myc. Uni· No. 560. 1876.
Under above name issues specimens collected in Saxony on *Salix cinerea* in 1874; gives *Sphaeria chlorospora* Ces. and *Sphaerella chlorospora* Ces. et De Not. as synonyms.

72. **Winter, G.** *Venturia chlorospora* (Cesati). Rab. Krypt. Fl. 1^2: 436. 1887.
Gives synonomy, exsiccati, specific description and hosts but agrees with Rehm that under above name should be included what are now considered distinct species on Salix, Sorbus, Fraxinus, Pyrus, Ulmus, etc.

73. ***Fabricius, L.** Krankheiten der Nutzhölzer. Hollrung's Jahresb· Neuer. Leist. Geb. Pflanzenkr. **5**: 279-302. 1904 or 2?
According to Lind (No. 35, p. 520, 562) Fabricius treats of *Fusicladium saliciperdum* in this article on page 281.

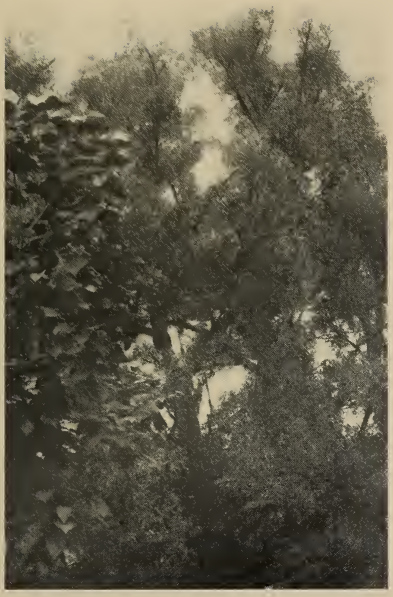
74. ***Ludwigs.** Lehrbuck der niederen Kryptogamen.
According to Tubeuf (No. 70, p. 570) Ludwigs gives reference to a serious outbreak on willow in Burgundy reported by Vuillemin.

75. ***Ludwigs u. Schmidt, M.** Biol. Reichs. Land-Forstw., Flugblatt No. 81.
According to Appen (No. 15, p. 67) they state *Fusicladium saliciperdum* injures willow trees.

76. ***Salmon, E. S.** Rept. S. E. Agr. Coll., Wye, Economic Myc. **1907**: 17?
Given here on authority of Mrs. Allcock (*q. v.* No. 5), but we have been unable to verify from reference given by her.

77. ***Wolff, M.** Abt. Pflanzenkr. Kais. Wilh. Inst. Landw. Bromb., Flugblatt No. 15.
According to Appen (No. 15, p. 67) Wolff states that *Fusicladium saliciperdum* injures willow trees.

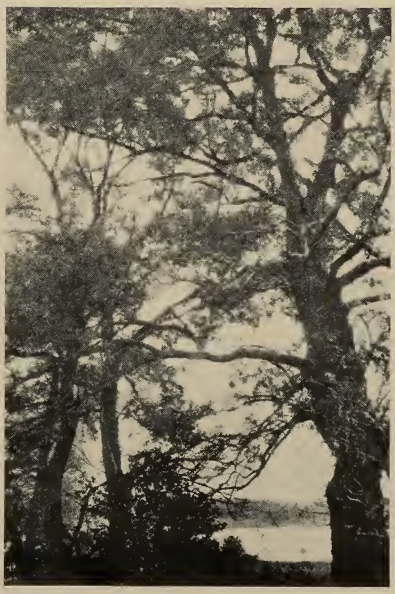
78. ***Undet. Author.** Abbauerscheinungen bei der amerikanischen Weide. Der Deutsche Korbweidenzüchter **1927**: 75-76. 1927.
See Review given under Anon. No. 14.



a. *Salix alba;* no disease.

b. *Salix* sp.; no disease.

c. *Salix* sp.; little disease.



d. *S. alba* var. *vitellina;* mod. disease.

WILLOWS WITH LITTLE OR NO DISEASED FOLIAGE.

PLATE X.

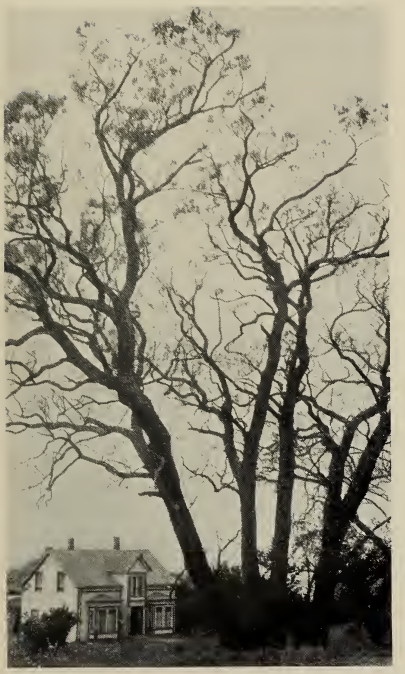
a. *Salix alba* var. *vitellina*.
Lawn trees, Norfolk.

b. *Salix alba* var. *vitellina*.
Street trees, Norfolk.

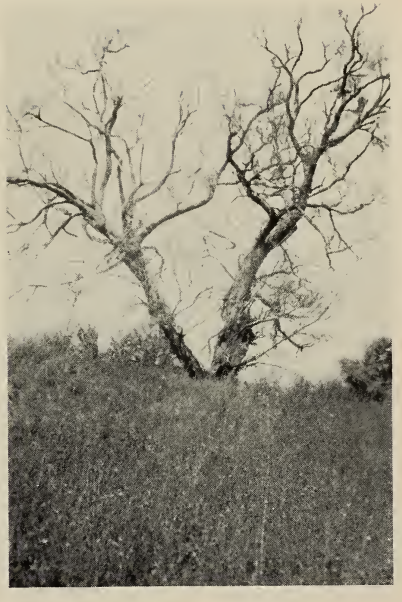
c. *Salix cordata*.
Bushes in swamp, Goshen.

d. *Salix alba* var. *vitellina*.
Trees along stream, Norfolk.

DISEASED WILLOWS (a, Photo, 1927; b-d, 1928) **FROM CONN.**

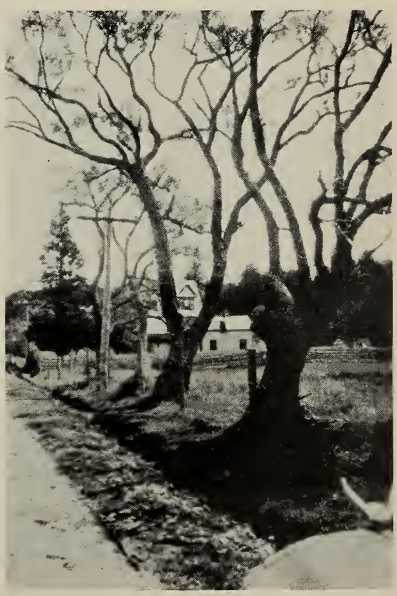


a. Street tree, Weymouth.



b. Pasture tree, Stewiacke.

c. Lighthouse Road, Digby.



d. Margaree, C. Breton.

DISEASED *Salix alba* var. *vitellina* **FROM NOVA SCOTIA.**
(a, c, Photos, 1927; b, d, 1928.)

a. New Haven, P. Edw. Isl.

b. Moncton, N. Brunswick.

c. Harrington, Me.

d. Salisbury Cove, Me.

DISEASED *Salix alba* var. *vitellina* **FROM CANADA AND MAINE, 1928.**

a. *Salix alba* var. *vitellina*, natural infection.

b. *Salix cordata*, artificially infected.

WILLOW LEAVES AND TWIGS SHOWING INJURY.

PLATE XIV.

a. Spray apparatus.

b. Spraying top of tree.

c. Sprayed tree.

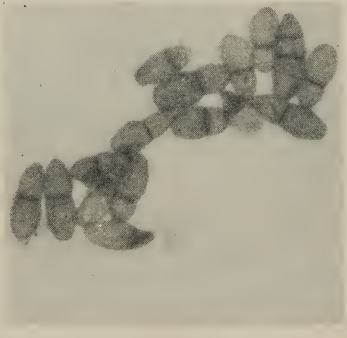
d. Check, unsprayed tree.

SPRAYING EXPERIMENTS AT NORFOLK, CONN., 1928.

a. Characteristic fruiting pustules on veins.

b. Culture.

c. Fruiting pustule.



d. Spores.

DETAILS OF, *Fusicladium saliciperdum*, **SCAB FUNGUS.**

(a, slightly; c, d, highly magnified).

PLATE XVI.

Inset, experimental plot. Main photo, details of one infection.

ARTIFICIAL INFECTION OF BASKET WILLOWS AT MT. CARMEL.